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(58) Field of search
H4L
Selected US specifications from IPC sub-classes H04B G08B

(54) **Tag device and method for electronic article surveillance**

(57) A tag device (10) comprises a substrate (12) which carries first circuit elements (14,16), transverse wings (18,20) and courses (22,24). The latter include longitudinal portions (22a,24a) transverse portions (22b,24b) and terminal portions (22c,24c). A diode (26) is connected in series with circuit elements (14,16). Additionally the substrate (12) carries second circuit elements (28,30) and include interior margin parts (28b,30b), and outer margin parts (28c,30c).

The first and second circuit elements are physically separate, electrically series connected and of different geometries for effecting predominant different receipt of first and second frequency transmitted signals.

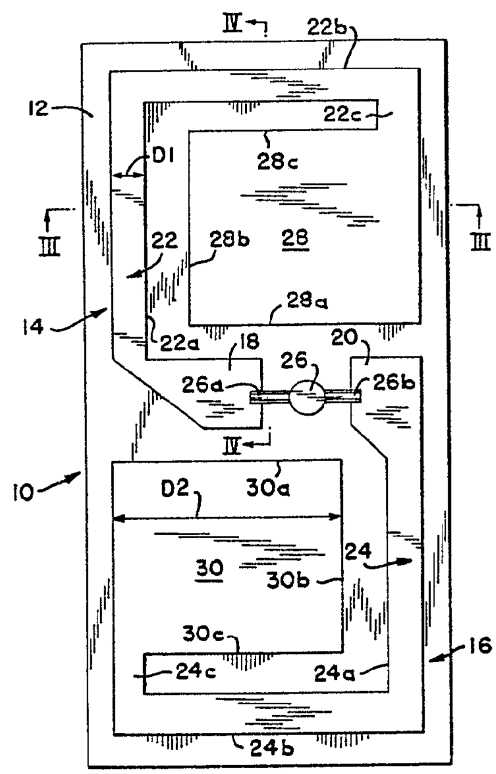

FIG. 1

The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

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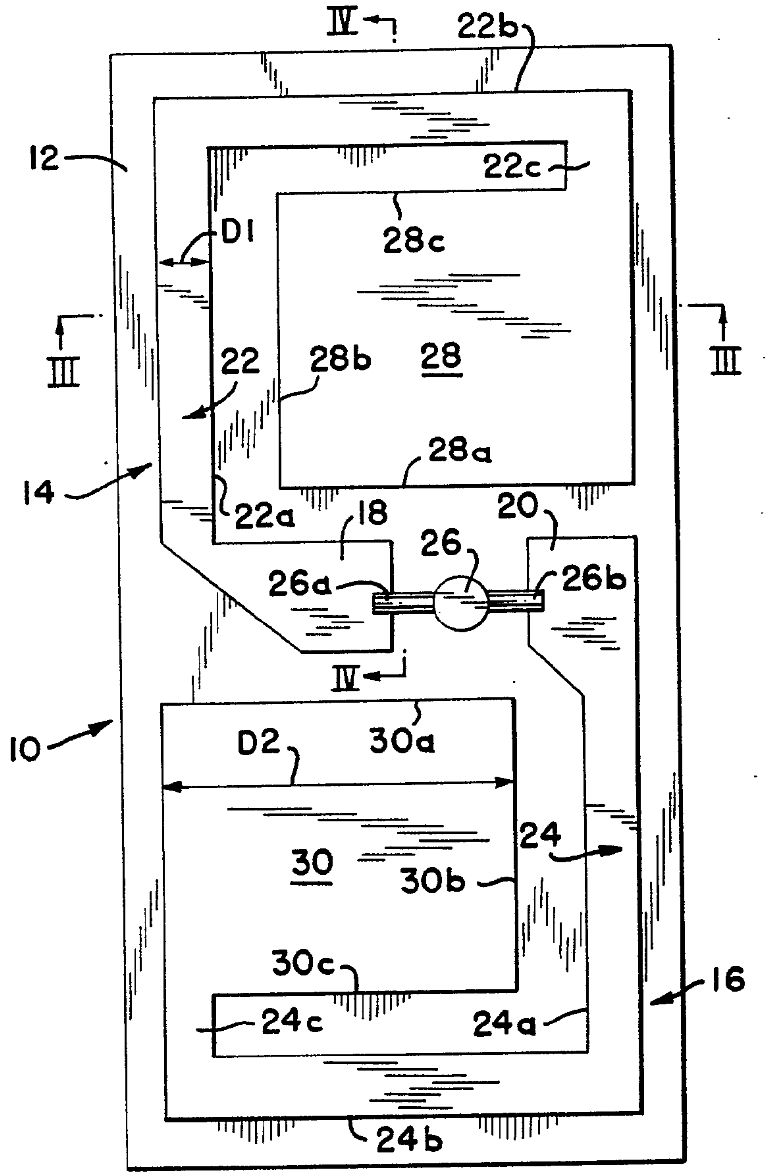

FIG. 1

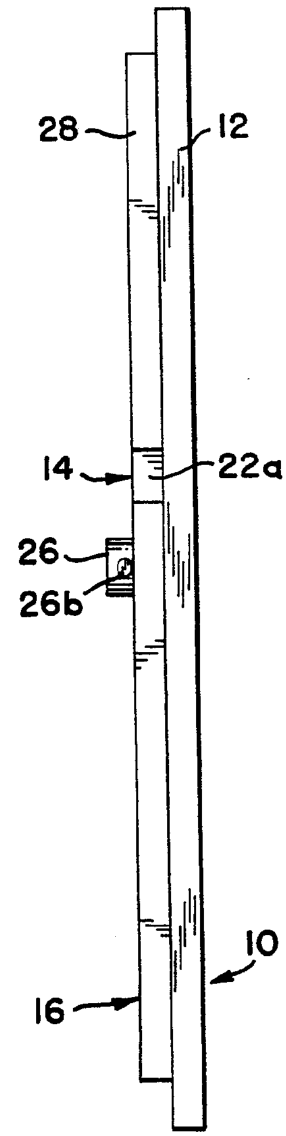

FIG. 2

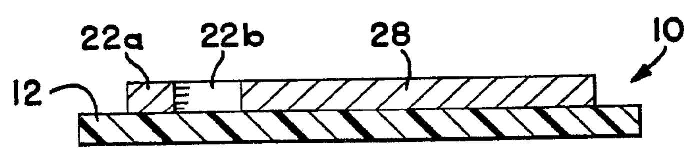

FIG. 3

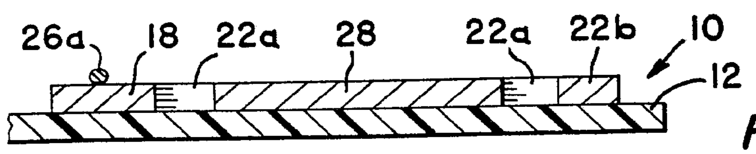

FIG. 4

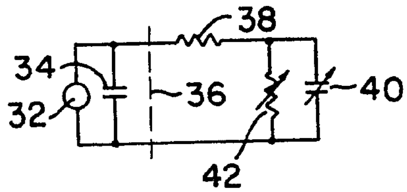

FIG. 5

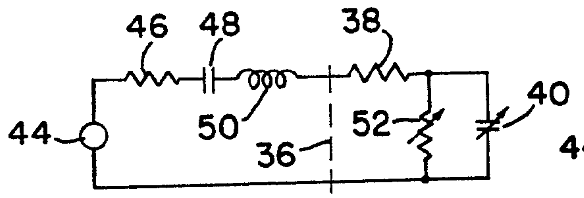

FIG. 6(a)

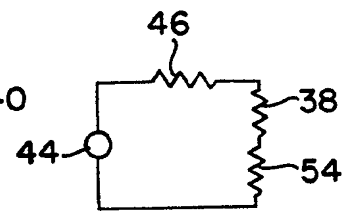

FIG. 6(b)

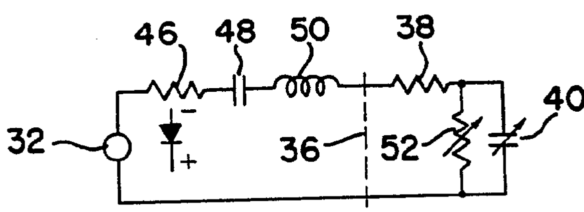

FIG. 7(a)

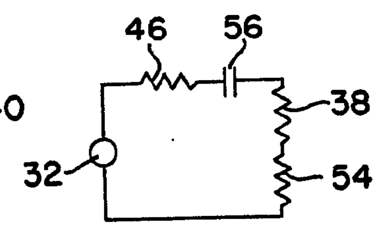

FIG. 7(b)

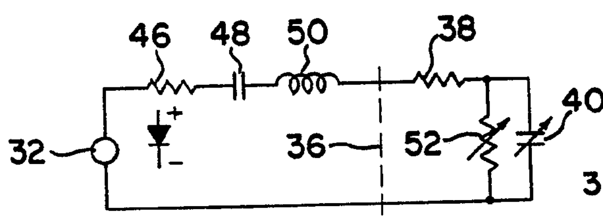

FIG. 8(a)

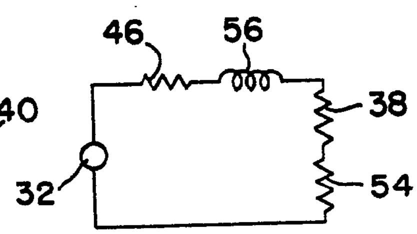

FIG. 8(b)

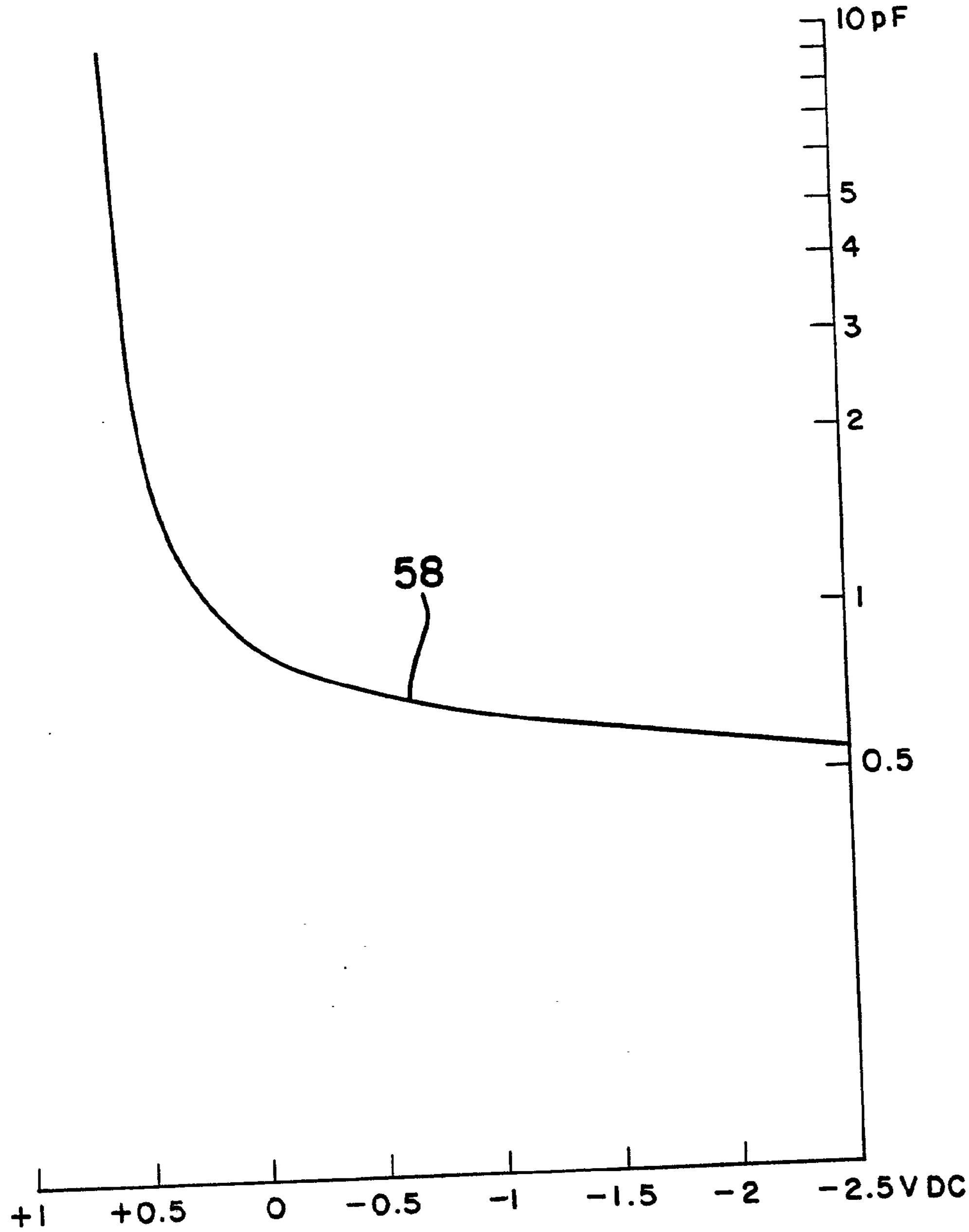

FIG. 9

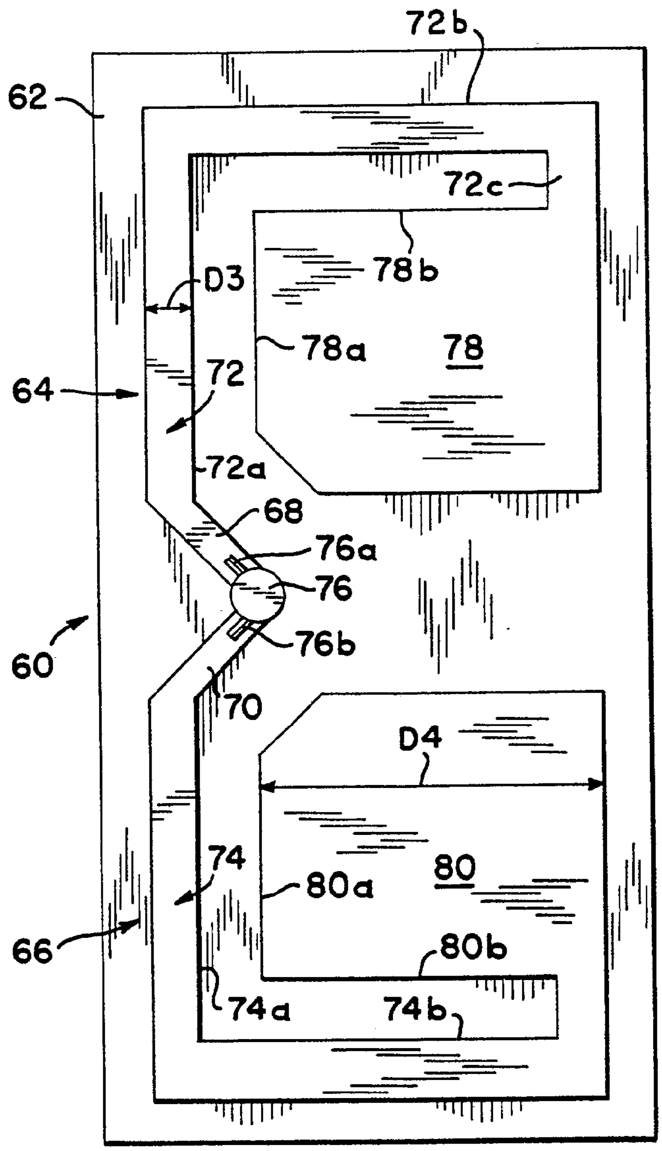
72b
62
72c
78b
D3
78a
78
64
72
72a
68
76a
76
76b
60
70
D4
74
80a
80
66
80b
74a
74b

FIG. 10

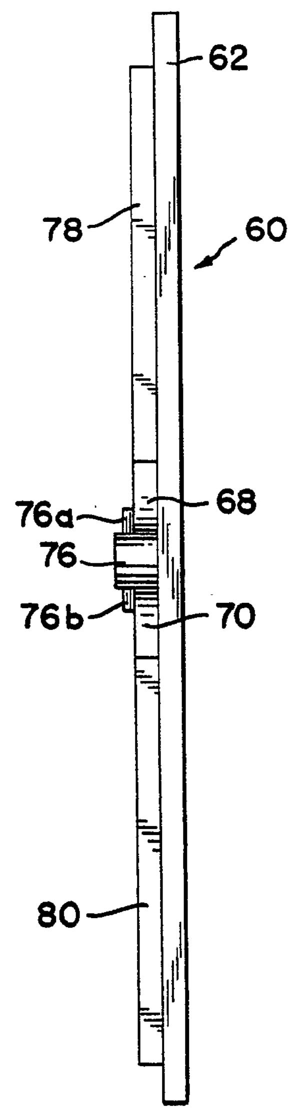
62
78
60
76a
68
76
76b
70
80

FIG. 11

SPECIFICATION

Tag device and method for electronic article surveillance

The present invention relates generally to tag devices and methods for use in electronic article surveillance and pertains more particularly to the provision of improved tag devices responsive to plural diverse frequency incident energy and to a method for electronic article surveillance with such tag devices.

The electronic article surveillance (EAS) industry has looked at large to tag devices of a type involving a dipole antenna housed with a diode in a protective envelope of insulative material. In some instances, EAS systems have provided for the transmission of a high frequency signal, such as a 915 MHz carrier, and of a lower frequency signal, such as modulated 100 KHz. Widespread understanding, as evidenced in United States Patent Specification No. 4,413,254, is that such device defines a so-called "receptor-reradiator", returning to the receiver of the EAS system, the 915 MHz carrier with content related to the lower frequency transmission and its modulation characteristic. Upon detection in the receiver of received signals inclusive of the modulation characteristic in given repetitive succession, an alarm indication is provided. Generally, detection takes place in a controlled zone, i.e., an exit area of a retail establishment, and output alarm indication is that of a tag device being carried therethrough without authorization (undeactivated).

Subsequent to the development referred to above, the art, particularly through research and development, has realized substantial analytical evaluation of the activity at hand in EAS dipole and dipole tag devices. Thus, in British Patent Specification No. 2,139,856, an appreciation flowing from such evaluation is stated, i.e., the need for the establishment of circuit parameters which maximize the reception of the various signals transmitted, the need for establishing an inductive tag device character at the high frequency, where length parameters otherwise dictate, and the need of having a resonant circuit in the tag device at the high frequency.

In addressing such descerned needs, the disclosure in British Patent Specification No. 2,139,856 looks to the addition of inductance at 915 MHz selectively, as by an inductive path providing same within the length constraint at hand. The disclosure thus looks not to the simple dipole/diode combination but to a discernment of specific diversely characterized tag device areas. The above referred to device thus provides a generally rectangular tag configuration and devotes area to a circuit element, which is inductive at the high frequency and is capacitive up to the lower frequency, and denotes other area to another circuit element, which is inductive at the high frequency, such circuit elements being physically disparate in geometry and arranged in electrical series circuit with the diode. In particular, the disclosure in the above referred to British Patent Specification, recognizes that the sum of the various reactances of the circuit elements and that of the diode should give rise to situations wherein the diode is at the centre of a resonant circuit, wherein the net sum of the various reactances at hand across the tag should then be zero and wherein the circuit elements should be addressed generally to different purposes, e.g., that one thereof should be such as to maximize second lower frequency energy receipt and hence voltage applied to the diode.

Apart from the various recognitions of the above referred to disclosure, it is believed that the art has not yet fully realized optimum parameters of tag devices responsive to plural frequency system transmissions.

It is an object of the present invention to provide improved tag devices responsive to plural frequency transmissions.

A further object of the invention is the provision of EAS tag devices having improved response to plural frequency transmissions from the viewpoint of tag device area allocation.

In one aspect of the present invention, there is provided in combination, in a tag device for use in a surveillance system for receipt of a first high frequency signal and a second lower frequency signal transmitted by such system, first and second circuit elements physically mutually separate, electrically series-connected and of respective different geometries for predominant receipt thereby respectively of said first and second frequency transmitted signals, said first and second circuit elements further being mutually coactive for enhancing such predominant signal receipts thereby.

In another aspect the present invention provides a method for effecting electronic article surveillance with a system high frequency signal and a second lower frequency signal, such second signal having a modulation characteristic therewith, and wherein generally rectangular tag devices are attached to said articles for receipt of such transmissions and for reradiation thereof, the method comprising the fabrication of said tag devices by the steps of:

(a) providing first and second circuit elements to be of type exhibiting fixed inductive and capacitive reactances;

(b) providing a third circuit element to be of a type exhibiting voltage dependent capacitive reactance and forming an electrical series circuit of the first, second and third circuit elements; and

(c) configuring the first and second circuit elements with respective geometric diversities, whereby the first circuit element extends longitudinally of the device and is of first transverse dimension, and whereby the second circuit element extends longitudinally of the device at least in part jointly spacedly with the first circuit element and is of second transverse dimension substantially exceeding the first transverse dimension, thus effecting predominantly different receipt by the first and second circuit elements of the first and second frequency transmitted signals.

Desirably, such spacing of the joint longitudinally extending courses of the first and second elements is selected to be of measure such that respective oppositely-directed currents exist in the first and second circuit elements at the first frequency, thereby further effecting said predominant diverse signal receipts thereby.

In a preferred form, following steps (a) and (b) above, step (c) is practiced by configuring the first and second circuit elements with respective geometric diversities, such that the second element predominates in receipt of such second frequency transmitted signals over receipt thereby by the first circuit element, and such that the series circuit is resonant at the first frequency, said step (b) being further practiced by selecting the third circuit element to coordinate the voltage dependent capacitive reactance thereof with the magnitude of second frequency transmitted signals received by the second circuit element to maximize capacitive reactance change in the third circuit element in response to such signals received by the second circuit element.

The present invention will now be described in greater detail by way of example with reference to the accompanying drawings, wherein:-

Figure 1 is a top plan view of a first embodiment of a tag device in accordance with the invention;

Figure 2 is a right side elevation of the tag device shown in Figure 1;

Figure 3 is a sectional view as would be seen from plane III-III of Figure 1;

Figure 4 is a sectional view as would be seen from plane IV-IV of Figure 1;

Figures 5 to *8(b)* show various tag device equivalent electrical circuits;

Figure 9 is a graph showing capacitance plotted to a base of voltage;

Figure 10 is a top plan view of a second embodiment of a tag device in accordance with the invention;

Figure 11 is a right side elevation of the tag device showin in Figure 10.

Referring to Figures 1 to 4, tag device 10 is of generally rectangular configuration and comprises an electrically insulative substrate 12 supporting various electrically conductive members. Such members comprise first circuit elements generally designated as 14 and 16, extending oppositely from the centre of device 10 and including respectively transverse wings 18 and 20 and courses 22 and 24 of first transverse dimension D1. Courses 22 and 24 each include longitudinal portions 22a and 24a extending to opposite ends of substrate 12, transverse portions 22b and 24b and terminal portions 22c and 24c. Diode 26 is connected by its leads 26a and 26b in electrical series circuit with first circuit elements 14 and 16.

The conductive members further include second circuit elements designated as 28 and 30 and of generally square outline and inclusive of respective transverse interior margin parts 28a and 30a, in spaced parallel relation with wings 18 and 20, respective longitudinal interior margin parts 28b and 30b, in spaced parallel relation with first circuit element portions 22a and 24a, and respective transverse outer margin parts 28c and 30c, in spaced parallel relation with first circuit element portions 22b and 24b. Second circuit elements 28 and 30 are electrically continuous with terminal portions 22c and 24c of the first circuit elements 22 and 24.

The transverse dimension of second circuit elements 28 and 30, indicated at D2, is substantially in excess of the transverse dimension D1 of first circuit elements 22 and 24, typically some five or more times D1, the geometric diversities of such circuit elements being assigned with a view toward providing selective different fixed inductive and capacitive reactances therein at the first and second frequencies received by tag device 10.

In this connection, second circuit elements 28 and 30 are dedicated or allocated, within the real estate constraints of tag device 10, to the reception of energy at the second transmitted system frequency (lower frequency) with modulation characteristic, for application thereof to diode 26. On the other hand, first circuit elements 22 and 24 have configuration selected such as to render the full series circuit of tag device 10, i.e., second circuit elements 28 and 30, diode 26 and first circuit elements 22 and 24, resonant at the first or high (microwave) frequency.

Circuit element configuration in accordance with the invention is also practiced with a view further to effect the predominant different frequency receptive character of the components of the tag device. Thus, a mutual coaction is desirably provided as between the first and second circuit elements for such purpose. In Figure 1, the second circuit element longitudinal interior margin parts 28b and 30b in spaced parallel relation with first circuit element portions 22a and 24a, and respective transverse second circuit element outer margin parts 28c and 30c in spaced parallel relation with first circuit element portions 22a and 24a, and respective transverse second circuit element outer margin parts 28c and 30c in spaced parallel relation with first circuit element portions 22b and 24b, respectively oppositely-directed edge-coupled mode currents are produced in the first and second circuit elements upon system transmission receipt by the tag device.

It has been determined that particular characteristics of the central (third) tag device circuit element are of significance to tag device response in the type of system under discussion, i.e., of plural transmitted frequency variety. In particular, it has been found that the voltage-dependent character of the third circuit element, previously known to be a diode, with respect to its capacitance change, is of consequence. The art, to date, has found diodes to be generally usable, for example, see the disclosure in United States Patent Specification No. 4,413,254 for usage of any one of Schottky, junction or PIN diodes.

It has been determined that the third circuit element is of consequence particularly in connection with its capacitance change as selected in correlation with the magnitude of energy receipt at second lower frequency by the tag device second circuit element. In contrast to other diodes, the PIN diode has such characteristic. Thus, given that the tag device is resonant at the first frequency, transitions occur as respects third circuit element capacitance with second frequency voltage excursions and this gives rise to phase shift reversals in the third circuit element.

These findings will be further understood from consideration of Figures 5 to 8(b) in which various equivalent electrical circuits of the tag device are shown.

Referring to Figure 5, same shows an equivalent circuit of the tag device generally in response to receipt of the lower frequency signal, as represented by reference numeral 32, comprising the voltage of second circuit elements 28 and 30 impressed across the tag device. At the lower frequency, the first and second circuit elements, which also comprise a dipole antenna, define essentially a pure capacitor 34, typically of the order of 1pF, giving rise to a capacitive reactance of 1.6 megohms at the lower frequency. Line 36 has the antenna leftwardly thereof and the remainder of the tag device rightwardly thereof. The diode has a small substrate series resistance 38, of the order of two or four ohms, insignificant at the lower frequency.

Diode capacitance 40, which is a function of applied voltage, is thus shown as variable. The capacitance range may vary, for example, from 0.5 to 5 pF, resulting in capacitive reactance change from 3.2 megohms to 320,000 ohms at the lower frequency, a change approximately of an order of magnitude.

Resistance 42 is the diode resistance, also a function of applied second frequency voltage, and may vary from 10 megohms to 10,000 ohms. The so-called Q-factor is dependent on the capacitances 34 and 40 and resistance 42 and is principally dependent on resistance 42, which should be maximized.

The equivalent circuit of Figure 6(a) represents the tag device of the invention generally in response to receipt of the high frequency signal, as represented by reference numeral 44. Within length constraints on the antenna of tag device 10, it is electrically of insufficient length at the first high frequency signal, and defines an equivalent circuit inclusive of resistance 46 and capacitance 48 and inductance 50, constituted by first circuit element 14 and 16, and second circuit elements 28 and 30. Resistance 38 is significant at the first high frequency, due to low impedance levels on each side of the diode.

Resistance 52 is the dynamic resistance of the diode and, unlike diode substrate resistance, is a function of applied voltage. The absolute value, however, is quite different, varying from 1 megohm to 1 kolohm. The Q-factor is directly affected by resistance 52, which should thus be as high as possible.

Figure 6(b) is a simplified version of the Figure 6(a) equivalent circuit, resistance 54 being the equivalent series component of parallel resistance 52. As will be seen, the reactances of capacitance 48 and inductance 50 cancel one another and the tag device is resonant and resistive at such first high frequency.

In Figure 7(a) is shown the equivalent circuit of the tag device at the lower frequency under its half-cycles wherein the diode is reverse-biased. The value of diode capacitance 40 is at a minimum, giving rise to a maximum capacitive reactance, which exceeds the inductive reactance of inductance 50. The tag device thus is capacitive, the uncancelled capacitive reactance being indicated by capacitance 56 in the simplified equivalent circuit of Figure 7(b).

Figure 8(a) shows the equivalent circuit of the tag device at the lower frequency under its half cycles wherein the diode is forward-biased. Here, diode capacitance 40 is at a maximum, and the tag device capacitive reactance is at a minimum. The tag device is now inductive, the uncancelled inductive reactance being indicated by inductance 56 in the simplified equivalent circuit of Figure 8(b).

The events of Figures 7(a) and 8(a) are cyclic with the lower frequency and the attendant phase reversal of load impedance produces sidebands for detection in the system receiver. The high frequency carrier is of course reradiated through the activity in Figure 6(a).

Figure 9 is a graph showing a desired characteristic for the tag device central or third circuit element, discussed to this point as a PIN diode 26. Curve 58 indicates third circuit element capacitance variation in relation to voltage thereacross. For negative applied voltage, capacitance is in the range of from about 0.55 pF to about 0.9 pF, for a voltage change of two and one-half volts. Substantially greater change is seen for positive applied voltage.

Of particular interest is the voltage range which corresponds to voltage generated in the tag device in response to the lower frequency signal, typically plus and minus one-half volt. The negative excursion has associated therewith capacitance change from 0.75 pF to 0.9 pF. The positive excursion has associated therewith capacitance change from 0.9 pF to 3.5 pF. The capacitive ratio change is approximately four-fold. With an excursion of minus six-tenths to plus six-tenths, the capacitance ratio change is more than an order of magnitude.

In manufacturing tag devices constructed in accordance with the invention, one correlates the tag capability for voltage generation at the lower frequency with capacitance change of the third circuit element, and vice versa, to enhance the magnitude of the phase reversals, above discussed, which generate the sidebands.

Referring to Figures 10 and 11, tag device 60 is of generally rectangular configuration and comprises an electrically insulated substrate 62 supporting various electrically conductive members. Such members comprise first circuit elements generally designated as 64 and 66, extending oppositely from the centre of device 60 and including respectively angled wings 68 and 70 and courses 72 and 74 of first transverse dimension D3. Courses 72 and 74 each include longitudinal portions 72a and 74a extending to opposite ends of substrate 62, transverse portions 72b and 74b and terminal portions 72c and 74c. Diode 76 is connected by its leads 76a and 76b electrical series circuit with first circuit elements 64 and 66.

The conductive members further include second circuit elements designated as 78 and 80 and of generally square outline and inclusive of respective longitudinal interior margin parts 78a and 80a, in spaced parallel relation with first circuit element portions 72a and 74a, and respective transverse outer margin parts 78b and 80b, in spaced parallel relation with first circuit element portions 72b and 74b. Second circuit elements 78 and 80 are electrically continuous with terminal portions 72c and 74c of first circuit elements 72 and 74.

The transverse dimension of second circuit elements 78 and 80, indicated at D4, is substantially in excess of the transverse dimension D3 of first circuit elements 72 and 74, typically some five or more times D3, the geometric diversities of such circuit elements being assigned as in tag device 10, with a view toward providing selective different fixed inductive and capacitive reactances therein at the first and second frequencies received by tag device 60.

An overlying insulative layer (not shown) is secured to each of insulative substrates 12 (Figure 1) and 62 (Figure 10) and provision is made for suitably deactivating the tag devices, as by providing access to the conductive members for applying a destructive energy pulse to the diode or other third circuit element.

CLAIMS

1. In combination, in a tag device for use in a surveillance system for receipt of a first high frequency signal and a second lower frequency signal transmitted by such system, first and second circuit elements physically mutually separate, electrically series-connected and of respective different geometries for predominant receipt thereby respectively of said first and second frequency transmitted signals, said first and second circuit elements further being mutually coactive for enhancing such predominant signal receipts thereby.

2. The combination according to claim 1, further including a generally rectangular substrate supporting said first and second circuit elements.

3. The combination according to claim 2, wherein said first circuit element extends longitudinally of said substrate and is of a first dimension transversely of said substrate.

4. The combination according to claim 3, wherein said second circuit element extends longitudinally of said substrate and is of a second dimension transversely of said substrate, said second dimension substantially exceeding said first dimension.

5. The combination according to claim 4, wherein said first circuit element and said second circuit element extend in mutually spaced facing relation longitudinally of said substrate, such spacing being of a measure providing for respective oppositely-directed currents therein at said first frequency, thereby effecting such enhancement of said predominant signal receipts thereby.

6. The combination according to claim 2, wherein said first circuit element includes first and second portions extending longitudinally of said substrate respectively toward opposite ends of said substrate, each of said first adnd second portions being of a first dimension transversely of said substrate.

7. The combination according to claim 6, wherein said second circuit element includes first and second parts extending longitudinally of said substrate respectively toward said opposite ends of said substrate, each of said first and second parts being of a second dimension transversely of said substrate, said second dimension substantially exceeding said first dimension.

8. The combination according to claim 7, wherein said first portion of said first circuit element and said first part of said second circuit element extend in mutually spaced facing relation longitudinally of said substrate, and wherein said second portion of said first circuit element and said second part of said second circuit element extend in mutually spaced facing relation longitudinally of said substrate, each such spacing being of a measure providing for respective oppositely-directed currents in said first and second circuit elements at said first frequency, thereby effecting such enhancement of said predominant signal receipts thereby.

9. The combination according to claim 8, further including means for electrically interconnecting said first and second portions of said first circuit element, said means exhibiting capacitive reactance dependent upon voltage applied thereto.

10. The combination according to claim 9, wherein said means comprises a PIN diode.

11. The combination according to claim 1, further including means for defining a series electrical circuit with said first and second circuit elements, said means exhibiting capacitive reactance dependent upon voltage applied thereto.

12. The combination according to claim 11, wherein said means comprises a PIN diode.

13. A method for effecting electronic article surveillance with a system high frequency signal and a second lower frequency signal, such second signal having a modulation characteristic therewith, and wherein generally rectangular tag devices are attached to said articles for receipt of such transmissions and for reradiation thereof, the method comprising the fabrication of said tag devices by the steps of:

(a) providing first and second circuit elements to be of type exhibiting fixed inductive and capacitive reactances;

(b) providing a third circuit element to be of a type exhibiting voltage dependent capacitive reactance and forming an electrical series circuit of the first, second and third circuit elements; and

(c) configuring the first and second circuit elements with respective geometric diversities, whereby the first circuit element extends longitudinally of the device and is of first transverse dimension, and whereby the second circuit element extends longitudinally of the device at least in part jointly spacedly with the first circuit element and is of second transverse dimension substantially exceeding the first transverse dimension, thus effecting predominantly different receipt by the first and second circuit elements of the first and second frequency transmitted signals.

14. The method according to claim 13, wherein said spacing between said joint longitudinally extending first and second circuit elements is selected to be of a measure such that respective oppositely-directed currents exist in said first and second circuit elements at said first frequency, thereby further effecting said predominant signal receipts thereby.

15. The method according to claim 13, wherein following steps (a) and (b) above, step (c) is practiced by configuring the first and second circuit elements with respective geometric diversities, such that the second element predominates in receipt of such second frequency transmitted signals over receipt threby by the first circuit element, and such that the series circuit is resonant at the first frequency, said step (b) being further practiced by selecting the third circuit element to coordinate the voltage dependent capacitive reactance thereof with the magnitude of second frequency transmitted signals received by the second circuit element to maximize capacitive reactance change in the third circuit element in response to such signals received by the second circuit element.

16. A tag device for use in a surveillance system constructed substantially as herein described with reference to and as illustrated in the accompanying drawings.

17. The method of effecting electronic article surveillance substantially as herein described with reference to the accompanying drawings.

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